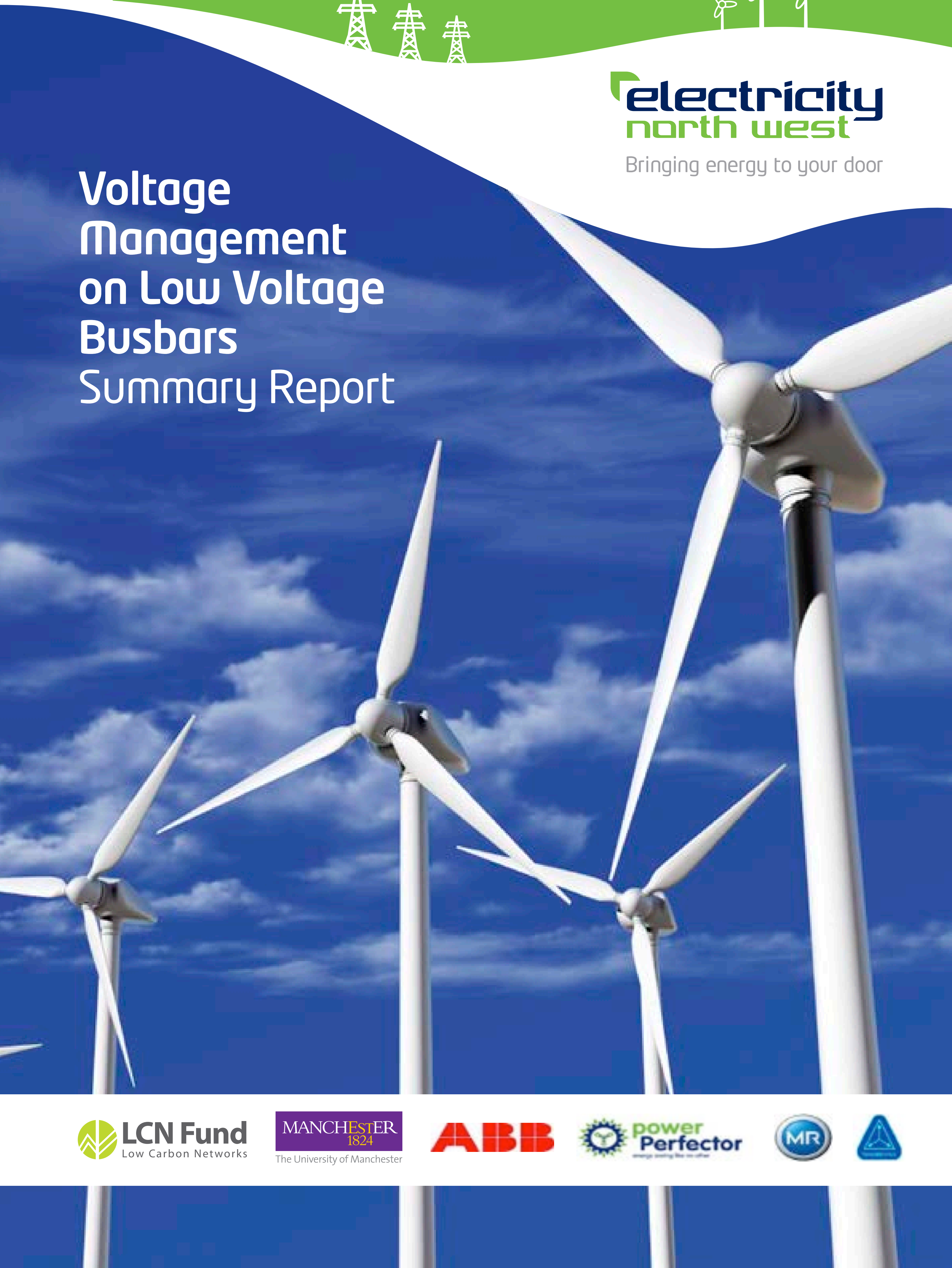
electricity north west

Bringing energy to your door

Voltage Management on Low Voltage Busbars

Summary Report



LCN Fund Low Carbon Networks · MANCHESTER 1824 The University of Manchester · ABB · power Perfector · MR

Voltage Management on Low Voltage Busbars was a three year project completed in January 2014 and is one of seven Electricity North West projects funded by the First Tier of the Low Carbon Networks Fund.

The project successfully deployed a range of voltage management technologies / techniques across a number of sites on our low voltage (LV) network. We installed distribution transformers with on-load tapchangers, voltage optimisers, capacitors and active filters on six distribution substations and their associated networks.

In conjunction with the deployment phase, the University of Manchester developed sophisticated, validated network models to allow simulations to be performed. These simulations allowed the project to explore a number of scenarios not possible during the trials including the effects of future load patterns. The monitoring equipment developed and installed under our Low Voltage Network Solutions project was used to support the trials and provide data for validation purposes.

The project has successfully shown that through the use of techniques such as distribution transformers with on-load tapchangers and LV capacitors, voltages can be effectively managed on low voltage systems to support the connection of increased low carbon technologies.

The successful conclusion of this project has led us to take LV voltage control a stage further through the Low Voltage Integrated Automation (LoVIA) First Tier project. The technique will be further integrated into our network as part of the Second Tier project, Smart Street.

Background

The decarbonisation of energy production, transport and heating is expected to result in significant increases in electricity demand. As the demand on the network increases, the likelihood of line voltage falling below acceptable thresholds becomes increasingly likely. In addition, the expected increase in penetration of domestic forms of generation such as photovoltaic panels (PV) is likely to give rise to line voltage exceeding acceptable thresholds during periods of low demand. It is expected that fluctuations in line voltages will need to be addressed if appropriate voltage quality is to be maintained and reinforcement avoided.

Technology deployment

The devices we installed can be categorised into the following areas:

- **Voltage regulation**
  Two distribution transformers with on-load tapchangers
  Two voltage optimisers (powerPerfector Plus)
- **Reactive compensation**
  Eight LV capacitors
- **Voltage quality**
  Two active harmonic filters

The technologies were purchased, as far as possible, using our standard specifications and procurement procedures.

To choose the most appropriate sites for the deployment we carried out an analysis of our distributed generation (DG) database to identify locations of clusters of PV generation.

Distribution transformer with on-load tapchanger

LV capacitor

All of the technologies were installed so that the system could be returned to 'normal' operation quickly in the event that the technology did not operate as intended. To aid this, a suite of operational procedures was introduced to the business.

Technology modelling

The University of Manchester created detailed mathematical models for all the technologies deployed in PSCAD/EMTDC. For some of the technologies, namely tapchangers and capacitors, models already existed and only required modification to suit our application. The models for the other technologies did not exist and were created from scratch.

The University also created models of the networks where the equipment was installed using our Geographical Information System (GIS) as a basis. Measurement data from the site trials were used to validate the models for all modes of operation. Simulations were run to assess the effectiveness of the different techniques with varying demand and generation penetrations to represent today's and future networks. In addition to the techniques undergoing physical trial, the University ran simulations using storage as a technique to manage the voltages on the network.

Project results

Each of the techniques investigated has proven useful in managing voltages on a low voltage network although some have more benefits than others. This section will highlight only some of the results.

The results show that implementing capacitor banks along a feeder produced reactive power and further boosted the network voltage. The size of the capacitor bank should always be less than the size of the transformer, to prevent reverse power flow and the creation of resonant current. By controlling the network voltage we can see an effect on the capacity released as shown right.

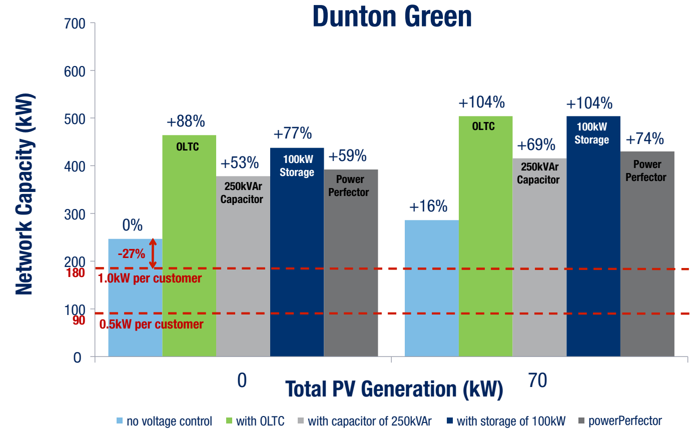
It is noted that the network capacity does not always increase with the higher rated capacitor banks. There is an optimum size of capacitor for a particular type of network. The amount of capacity released will depend on how resistive the network is and it may be that for some networks a capacitor is not the most effective solution.

Comparison of the different techniques shows that a transformer with an on-load tapchanger can offer a significant increase in network capacity while offering effective voltage regulation. However, this is not necessarily always the most effective method, as the effectiveness of voltage control is also largely dependent on network conditions. For example, where there are several feeders connected to a single substation and one of the feeders has a significantly higher volt drop at the end of the feeder, it could be more effective to use a feeder solution such as storage or capacitors.

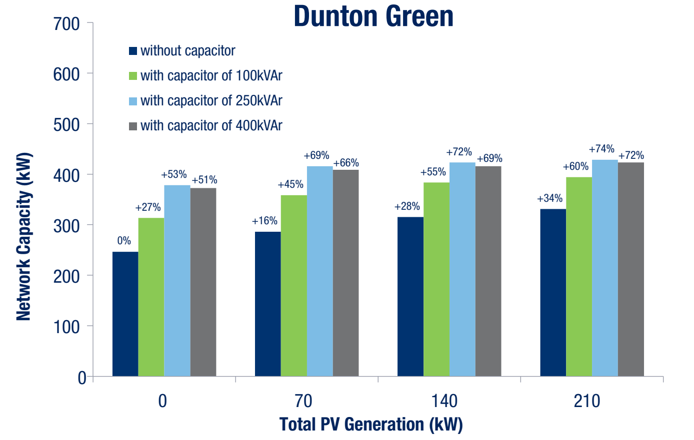
While there is no significant driver to introduce voltage control equipment on every feeder at present, these techniques have proven to be of use. The need will increase in proportion to the uptake of distributed generation and loads such as electric vehicles.

For more details see our closedown report at:
electricitynorthwest.co.uk/lvbusbars

Dunton Green network capacities with various voltage control devices



Network capacities with different capacitors installed on the feeder



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